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Using digital technologies for classification of domestic pigs by the type of live weight growth

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***Abstract*— This publication identifies the problem of classification of domestic pigs by type of growth intensity and final live weight. It is shown that the existing classification allows quite flawed examples of representatives of separate classes. The authors of this article decided to enhance the existing classification with the sorting of representatives within each cluster on the basis of literature reports. Large fast-growing, large slow-growing, small fast- growing, and small slow-growing types of pig growth were identified. The most specific representatives of each cluster were indicated. For the experimental verification of produced proposition, the growth dynamics of several samples of domestic pigs were estimated using relative live weight at different growth stages, growth visualization on graphs, as well as regression equations. The results of all methods showed a fairly clear differentiation of domestic pigs into small and large types. The identifying of fast- and slow-growing types within each group was very conditional. The main reason for the poor knowledge of this topic is the actual complexity of the mathematical description of growth. Some methods, for example, regression analysis, are to some extent time consuming when calculating in the traditional way, without using modern software.**

Keywords*— *growth types, live weight, pigs, large breeds, mini pigs.

I. INTRODUCTION

The problem of the growth of domestic pigs was already studied in the 70s - 80s of XX century [1]. The different methods of the classification of domestic pigs by growth types stands out. According to one hypothesis, the division into large and small types is quite sufficient [2]. Traditional classification system [1] suggests the division of domestic pigs by live weight growth type into four categories: large fast-growing, large slow-growing, small fast-growing, slow-growing. However, the examples given turned out to be extremely flawed – all pigs belong to modern stud breeds and the principle of their distribution into the proposed categories is not quite clear. After studying the literature [3-7] which describes the living weight of different pigs at a different age, it was decided to complete and to improve this classification as follows.

1. Large fast-growing type is the most progressive type of modern domestic pig. It is characterized by the live weight of adult boars of 320–350 kg and of full-aged sows of 220–250 kg. This category of domestic pigs is characterized by very intensive weight gain up to 8–12 months of age; this period is called "the period of intensive growth" [2]. Characteristic representatives of large fast-growing pigs are modern commercial breeds Landrace, Duroc, Kemerovo, Lacombe, SM-1, Pietrain, and so on.

2. Large slow-growing type - adults with the live weight of 300 kg or more. However, their economic value was reduced due to the long period of growth. Fattening such pigs became reasonable not earlier than 2-3 years. This group of pigs includes old European long-eared selection groups. Their characteristic representatives were, in particular, English marsh pigs.

3. Small fast-growing type - this group includes breeds and breed groups of pigs that can grow up to 80-100 kg during the first year of life. However, in the future their growth practically stops. Live weight at 3 years does not exceed 150 kg. Their ability to grow intensively in the first year of life made this category of domestic pigs attractive for improving fattening qualities. This cluster includes cultural breeds of pigs bred in China and in the countries of Southeast Asia.

4. Small slow-growing type is the most archaic and primitive group retaining the maximum similarity to the primary domesticated pigs. Their live weight is within the limit of 150 kg. They have practically no period of intensive growth, and live weight gain dynamics of individual representatives tends to increase also after 36 months. This group includes some modern selection groups of laboratory mini pigs, preserved primitive breeds, as well as feral short-eared pigs.

One of the reasons for the lack of unified growth classification of pigs is the actual complexity of the mathematical description of growth. Some methods, for example, regression analysis, are to some extent time consuming when calculating in the traditional way, without using modern software. Computer technologies can significantly help with statistical and mathematical analysis, narrowing the work of researcher down to the correct input of initial data. Calculation algorithms are set in the program. The purpose of our work is to apply computer technologies

for clarifying the classification of growth types of domestic pigs.

II. Materials and Methods

To achieve this goal, several groups of domestic pigs belonging to different "weight" and economic categories were selected. Commercial breeds, large white and landrace, were during one and a half hundred years selected for large size and intensive growth [5]. In contrast, data were taken, on live weight in a different age of representatives of several selection groups of the so-called laboratory mini pigs: Svetlogorsk; American-Essex and mini pigs bred by Institute of Cytology and Genetics, Siberian Branch of the Russian Academy of Sciences. Data on live weight were taken from literary sources [2, 7-9].

To estimate the general type of growth, we used the live weight of pigs at birth, at 2, 6, 12, 24, and 36 months. This is explained by the fact that pigs at 2 months of age are usually nursed taking into account their live weight; stud breed animals at 6 months, under optimal feeding conditions, reach the live weight of 100 kg [10]. The age of 12, 24 and 36 months is equivalent to 1, 2 and 3 years when live weight assessment was provided for breeding pigs [11].

On the basis of live weight data, an additional parameter was calculated - the relative live weight (RLW) which shows the ratio of the weight in the studied age (LWt) to the live weight at the age of 36 months (LW36mon). It is considered that further growth of pigs is minimal [1, 11]. The formula for RLW calculating is as follows:

$$RLW = \frac{LW_t}{LW_{36mon}} \times 100\%$$

With the help of Microsoft Excel 2007, graphs were constructed and regression equations were calculated that describe the growth of pigs. The approximation value (R^2) greater than or equal to 0.950 was taken as the fitting criterion.

III. Results and Discussion

Differences in relative live weight, albeit slight, between large breeds and laboratory mini pigs appeared even at birth. Characteristic variation in large breeds (large white and landrace) ranged from 0.38 to 0.55% relative to live weight at 36 months. In minipigs, piglets are born slightly larger relative to the weight of full-age animals, relative live weight of a newborn piglet is 0.63–1.39% (Table 1).

Growth visualization in graph form (Fig. 1) shows a clear distinction between large breeds, large white and landrace, and minipigs. In Svetlogorsk mini pigs, as well as in representatives of large breeds, growth intensity somewhat reduced starting from 12 months of age, it was not so obvious in American-Essex mini pigs and mini pigs.

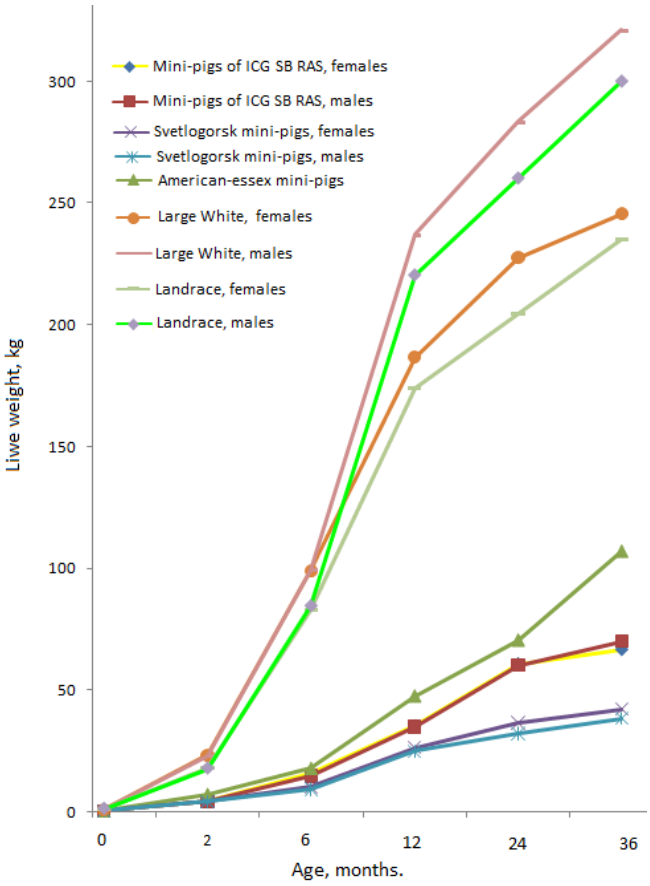

Fig. 1. Graph showing the growth of different groups of domestic pigs

Typological features of the growth of pigs start to become obvious only by the age of 12 months. In the samples of large white and landrace breeds, relative live weight was about 75% what can be accepted as a certain numerical expression of the growth jump shown at the graph (Fig. 1). Among mini pigs, no single type of growth can be observed.

TABLE I. Relative live weight (RLW, %) of various types of domestic pig

Sample	Parameter	Age, months					
		At birth	*2*	*6*	*12*	*24*	*36*
Mini pigs ICG, female [2]	Live weight, kg	0.72±0.015	4.42±0.14	16.19±0.65	35.58±1.19	60.96±1.97	66.79±5.44
	RLW, %	1.08	6.62	24.24	53.27	91.26	100.00
	n	154	70	70	23	23	10
Mini pigs ICG, male [2]	Live weight, kg	0.71±0.011	4.26±0.12	14.93±0.98	35.01±2.19	60.21±7.51	70.01±14.34
	RLW, %	1.01	6.08	21.31	50.01	86.01	100.00
	n	146	74	14	12	7	5
American-Essex mini pigs [7]	Live weight, kg	0.68	7.4	18.1	47.8	70.7	107.1
	RLW, %	0.64	6.90	16.91	44.64	66.02	100

	n	945	46	44	25	23	16
Svetlogorsk mini pigs, female [8]	Live weight, kg	0.59± 0.02	4.17±0.41	10.21±0.25	26.51±0.37	36.61±0.38	42.31±0.29
	RLW, %	1.38	9.84	24.12	62.63	86.53	100.00
	n	98	89	80	52	50	48
Svetlogorsk mini pigs, male [8]	Live weight, kg	0.54± 0.03	4.23±0.29	9.41±0.23	25.01±0.21	32.21±0.26	38.41±0.31
	RLW, %	1.39	11.00	24.49	65.11	83.86	100.00
	n	95	79	69	51	40	21
Large White, female [2]	Live weight, kg	1.21	23.41±3.95	99.26±1.23	186.91±7.24	227.61±4.42	245.55±2.44
	RLW, %	0.50	9.54	40.43	76.13	92.70	100.00
	n	–	10	53	10	43	113
Large White, male [2]	Live weight, kg	1.21	23.15±2.10	99.24±1.07	236.92±7.69	283.46±6.45	321.01±10.69
	RLW, %	0.39	7.20	30.90	73.81	88.32	100.00
	n	–	7	56	23	22	13
Landrace, female [7, 9]	Live weight, kg	1.25±0.0015	18.31± 0.41	83.15± 1.23	174.11± 2.41	–	235
	RLW, %	0.55	7.80	35.38	74.10		100.00
	n	18114	78	30	31		–
Landrace, male [7, 9]	Live weight, kg	1.31± 0.002	17.91± 0.32	84.59± 1.12	220.41± 6.31	–	300
	RLW, %	0.45	5.98	28.20	73.48		100.00
	n	18029	85	34	9		–

The minipigs of the Institute of Cytology and Genetics of the Siberian Branch of the Russian Academy of Sciences and American-Essex mini pigs have shown themselves to be representatives of the small slow-growing type. Their relative live weight at 1 year ranged from 44.63 to 53.26%. For comparison, we give the live weight of some old breed groups of short-eared pigs. Adult Morshansk pigs had the live weight of 90–120 kg, one-year-old pigs – 60–70 kg, polydactyl pigs weighed 84 kg (one-year – 56 kg), tridactyl - 79 kg (one year – 40 kg) [4]. Thus, the relative live weight of Morshansk pigs at the age of 12 months was 61.90%, of polydactyl - 66.67%, of tridactyl - 50.63%. Consequently, the proposition that modern European and American mini pig is a reconstructed small primitive short-eared pig [12] is confirmed due to one of the key indicators of the intraspecific classification of pigs - growth features. Comparison of the growth of large and small pigs using regression analysis also revealed some interesting facts (Table 2). So, regardless of the group, all samples can be described by a polynomial function. In addition, in samples with no possibility for describing by a linear (American-Essex mini pigs) or power (females of large white breed) equation, the approximation value was close to the accepted passing value (0.94 - 0.95). Thus, all samples, albeit with some assumptions, can also be described by linear and power functions. It should be noted that approximation range in power equations for the growth of pigs of large breeds was slightly lower than that in similar equations describing the growth of mini pigs (Table 2).

TABLE II. REGRESSION EQUATIONS DESCRIBING THE GROWTH OF PIGS

Sample	Regression equation	Equation type	R^2
Mini pigs ICG, females	$y=14.83x-21.16$	linear	0.953
	$y=1.62x^2+6.702x-10.32$	polynomial	0.965
	$y=0.751x^2$	power	0.990
Mini pigs ICG, males	$y=15.26x-22.59$	linear	0.952
	$y=1.595x^2+4.09x-7.703$	polynomial	0.965
	$y=0.718x^2$	power	0.993
American-Essex mini pigs	$y=3.521x^2+3.172x-0.34$	polynomial	0.995
	$y=0.819x^{2.812}$	power	0.991
Svetlogorsk mini pigs, female	$y=9.206x-12.16$	linear	0.965
	$y=0.479x^2+5.851x-7.692$	polynomial	0.969
	$y=0.666x^{2.471}$	power	0.987
Svetlogorsk mini pigs, male	$y=8.254x-10.59$	linear	0.965

	$y=0.368x^2+5.675x-7.159$	polynomial	0.969
	$y=0.636x^{2.445}$	power	0.982
Large White, female	$y=54.91x-61.54$	linear	0.965
	$y=-2.891x^2+75.15-88.53$	polynomial	0.965
Large White, male	$y=71.93x-90.93$	linear	0.956
	$y=-0.717x^2+76.95x-97.63$	polynomial	0.956
	$y=1.860x^{3.204}$	power	0.956
Landrace, female	$y=51.95x-62.44$	linear	0.962
	$y=-1.257x^2+60.75x-74.18$	polynomial	0.963
	$y=1.866x^{3.003}$	power	0.957
Landrace, male	$y=67.31x-88.21$	linear	0.950
	$y=0.153x^2+66.24x-86.78$	polynomial	0.951
	$y=1.797x^2$	power	0.967

In general, each of the methods used in one way or another showed the dividing of studied samples by the type of growth into small and large one. Identifying of fast- and slow-growing subtypes within each type is rather conditional; for establishing clear boundaries, it seems that massive study of the growth of pigs, including at least a dozen breeds and thousands of individuals, is required.

It has been shown that hundreds of loci are involved in genetic control of pig growth [13]. The study of biochemical processes of protein and lipid metabolism at the cellular level only confirms this point [14]. However, it was also suggested that the cause of the differences in the growth of small and large pigs may be the mutation of a single major gene [2] which may well be the somatotropin gene [15]. Apparently, the following concept seems to be the most reasonable: fundamental differences in the growth of small and large pigs are determined by a single mutation [2], and fast and slow growth within each type is provided by the polygenic complex. Moreover, this complex provides a very plastic variability of growth energy, which, with appropriate breeding, can be shifted towards fast-growing type which is quite reasonably consolidated in large breeds. At least, it is this complex that apparently provides variation in live weight of adults in the group of small pigs from 35–45 kg to 140–150 kg (Table 1). Miniature Pigs of ICG as a Model Object

for Morphogenetic Research

IV. Conclusions

1. Methods used for the analysis showed a clear differentiation of domestic pigs according to their nature of growth and live weight into small and large types.
2. Subdividing into slow- and fast-growing types is conditional, with the possibility of shifting towards the fast-growing type with appropriate selection

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